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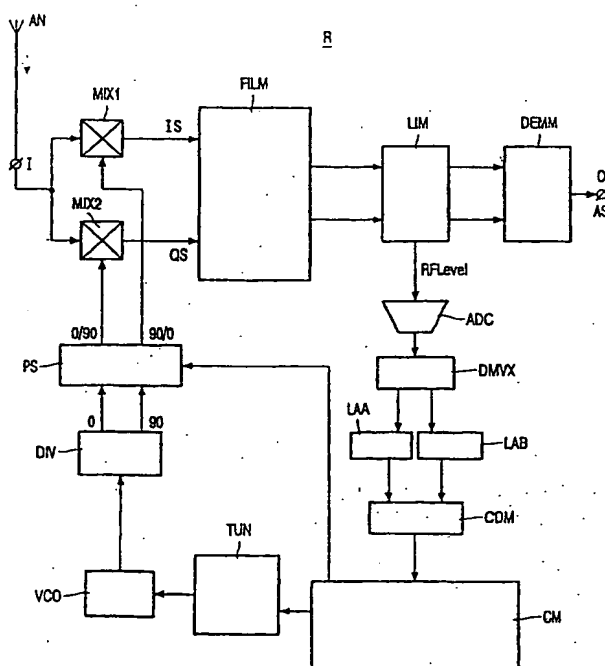
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(57) Abstract: Radio receivers are known in the art. A conventional receiver requires external components for RF/image selectivity, IF selectivity and demodulation. Other solutions are for example a number of correction algorithms, which is an expensive solution. The receiver according to the invention obtains a better rejection without the need of expensive algorithms.

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Image rejection.

The invention relates to a receiver as described in the preamble of Claim 1. The invention further relates to a method as described in the preamble of Claim 5.

Receivers are known in the art. A conventional receiver architecture requires external components for RF/image selectivity, IF selectivity and demodulation. To facilitate full integration of receivers, numerous novel architectures have been proposed. For a broadcast network where little or no information is present at the carrier frequency, for example GSM or DAB, the zero-IF architecture is a good solution. However, broadcast systems with much information at the carrier frequency, for example standard AM/FM broadcast can not tolerate the DC consequences of the conversion to zero frequency.

Therefore, the low IF architecture has been proposed to solve this problem. However, converting the signal to a very low IF has the drawback that no image rejection can be carried out prior to this frequency conversion. The remedy to this is to use this quadrature signal processing as is well known in the art. The limiting aspect of the quadrature low-IF architecture is that it delivers integrated image rejection based on matching of parameters, such as gain and phase, of the quadratures channels. In practice, the matching of components in an integrated circuit limits this to about 40 dB. Some applications, for example, the mono-portable FM radio can accept this limitation. But other applications, such as FM stereo for portable and car application, require at least 60 dB of image rejection. To solve this matching problem, a number of correction algorithms have been developed. Unfortunately, these algorithms are only suitable for digital realization. The extra cost involved in digitalization make these solutions out of reach for cheap portable radio type of applications for example.

From the European Patent EP-B-0 496 621 a receiver is known having a number of correction algorithms. Though this is an expensive solution certainly not suitable for cheaper applications such as portable radio receivers.

An object of the invention is to provide a receiver having additional effective image rejection suitable for all receiver realizations with very little additional complexity. This is achieved with a receiver according to the invention as described in Claim 1.

The idea of the invention is to position, at will, the "weak" image point at the side of the wanted channel with the lowest unwanted RF signal strength. In this way, also the actual image rejection of the circuit has not necessarily been increased, the actual perceived image rejection is clearly improved.

An embodiment of the invention comprises the features of Claim 2.

A further embodiment of a receiver according to the invention comprises the features of Claim 3.

A method according to the invention is described in Claim 5.

The invention will be described by way of example and elucidated with reference to the Figures hereinafter. Herein shows:

Figure 1 the IF channel characteristics of a prior art receiver without image rejection,

Figure 2 the IF channel characteristics of a prior art receiver with complex image rejection,

Figure 3 an example of a typical RF spectrum of the FM reception band,

Figure 4 an example of a receiver according to the invention, and

Figure 5 an example of IF channel characteristics of the receiver according to the invention.

Figure 1 shows the IF channel characteristics of a prior art receiver without image rejection and/or complex IF filtering. Here the IF is chosen to be 150 kHz (desired signal d) and the modulation is narrow-band FM for simplicity. From the Figure it is clear that the unwanted signals (image i at -150 kHz) are not rejected at all. This would cause unacceptable co-channel interference.

Figure 2 shows the IF channel characteristics of a prior receiver with complex image rejection. In the Figure the ideal situation is shown with the dashed line (no image i at -150 kHz). Also here the IF (desired signal d) is chosen to be 150 kHz and the modulation is narrow-band FM for simplicity. But as component-matching limitations will occur in real situations, this limited component matching in the integrated circuit will result in limited image rejection with an image at -150 kHz.

In Figure 3 an example of a typical RF spectrum of the FM reception band is shown. Herein it is illustrated that signal distribution has a random nature within the crowded

reception band. A close examination of such spectra reveals that a large unwanted signal at the image frequency distance can be present at either above or below the wanted signal, but almost never on both sides at the same time. This statistical distribution of the signals is utilized in this invention.

5 The idea of the invention is to position, at will, the "weak" image point at the side of the wanted channel with the lowest unwanted RF signal strength. In this way, although the actual image rejection has not necessarily been increased, the actual perceived image rejection is improved.

10 In Figure 4 a receiver R according to the invention is shown. This receiver comprises an input I for receiving an antenna signal from an antenna AN. The input I is coupled to a first and second mixer MIX1 respectively MIX2. At the other input the respective mixers receive a first and second oscillator signal from an oscillator VCO via a divider DIV and a phase selector PS. The operation will be described below.

15 The output of the mixer MIX1 supplies the so-called in-phase signal IS and the output of the mixer MIX2 supplies the so-called quadrature signal QS. Both outputs are coupled to respective inputs of filter means FILM.

20 The filter means supply a first and second output signal via a limiter LIM to demodulator means DEMM. After demodulation of the complex signal the demodulated signal is supplied to an output O for supplying an audio signal AS for example to loudspeakers (not shown).

25 The limiter LIM is also coupled to an A/D converter ADC for supplying a signal that is an indication of the RF level. The A/D converter is coupled to de-multiplexing means DMUX and first and second storing means LAA and LAB. The two stored values are compared in comparing means COM. The comparing means are coupled to a control CM for supplying a signal to the voltage controlled oscillator VCO via tuning means TUN. The control means further supply a signal to the phase selector PS for deciding which phase is chosen for the first and second mixer MIX1 and MIX2.

30 The pass-band position of the filter means FILM is determined by the In-phase and Quadrature (I/Q) signals, which are in turn defined by, amongst others the phase direction of the divided oscillator signals. The control means CM defines the divider output connections that set the phase relation.

 The tuning procedure for a wanted frequency F_a will now be as follows. First tune the receiver R to $F_a + 2 \times IF$ frequency, with an arbitrary but defined setting of the divider DIV output phase and the audio output O of the receiver muted. Note that the image

signal will be at a frequency distance of $2 \times \text{IF}$ from the wanted signal. Then measure the RF level of this unwanted signal. This can be done by standard RSSI type of circuitry, often incorporated in a limiter LIM. This measured RF level value is stored in a memory. A simple implementation is as shown in Figure 4, where first the RF level is converted from analogue to digital with the A/D converter ADC, followed by de-multiplexing in the de-multiplexer DMUX and storing in a latch, for example the first latch LAA.

After this the receiver is then tuned to $F_a - 2 \times \text{IF}$, with the same phase of the divider DIV and the audio signal still muted. Again the RF level signal is measured and stored in the second latch LAB. The IF transfer characteristics for this mode is shown in Figure 5.

The results of these RF signal strength measurements are then compared to determine the position of the lower interfering signal.

The receiver is then tuned to the actual F_a frequency, with the control means CM setting the divider DIV output phase such that the image of the filter means would fall at this lower interfering signal. The tuning operation is now complete and the audio signal is demuted.

Therefore each tuning operation of a receiver of method according to the invention is subdivided into 3 separate steps; 2 measurement steps and a final tuning step. The coordination of the individual steps is carried out automatically by the control algorithm of the control means CM. Preferably the user is unaware of these separate operations, since they are carried out during the customary audio-mute period of the tuning operation. Although the image rejection can not be expressed in exact Figures, typical spectral measurement (see Figure 3) suggest that effectively an extra 20 dB of image suppression is achievable. This makes the Low-IF architecture suitable for FM stereo applications.

The principles behind the above algorithm can also be applied to other receiver systems, regardless of the modulation scheme or IF choice.

CLAIMS:

1. Receiver comprising an input for receiving an antenna signal, an output for supplying an audio signal, first and second mixing means for mixing the antenna signal with a first and second oscillation signal to obtain an in-phase and quadrature signal, filter means for filtering the in-phase and quadrature signal, demodulation means for demodulating the filtered
5 quadrature signals and an oscillator for supplying the first and second oscillation signal to the first and second mixing means, characterized in that the receiver comprises measuring means for measuring a level of disturbance at a first and second predetermined frequency distance from the chosen frequency, comparing means for comparing the measured first and second level of disturbance, choosing means for choosing the frequency band with the lowest level of
10 disturbance, and a control means for controlling the oscillator..
2. Receiver according to Claim 1, characterized in that the control means further supply a control signal to a phase selector coupled between the oscillator and the mixing means.
15
3. Receiver according to Claim 1, characterized in that the measuring means comprise an A/D converter and a demultiplexer and further storing means for storing the measured level of disturbance(s).
- 20 4. Method for tuning a tuner to a predetermined frequency having a first and second measuring of a level of disturbance at the first and second predetermined frequency distance of the chosen frequency, a comparison of the first and second level of disturbance and a choosing of the frequency band with the lowest level of disturbance and a tuning of the receiver to the chosen frequency band.

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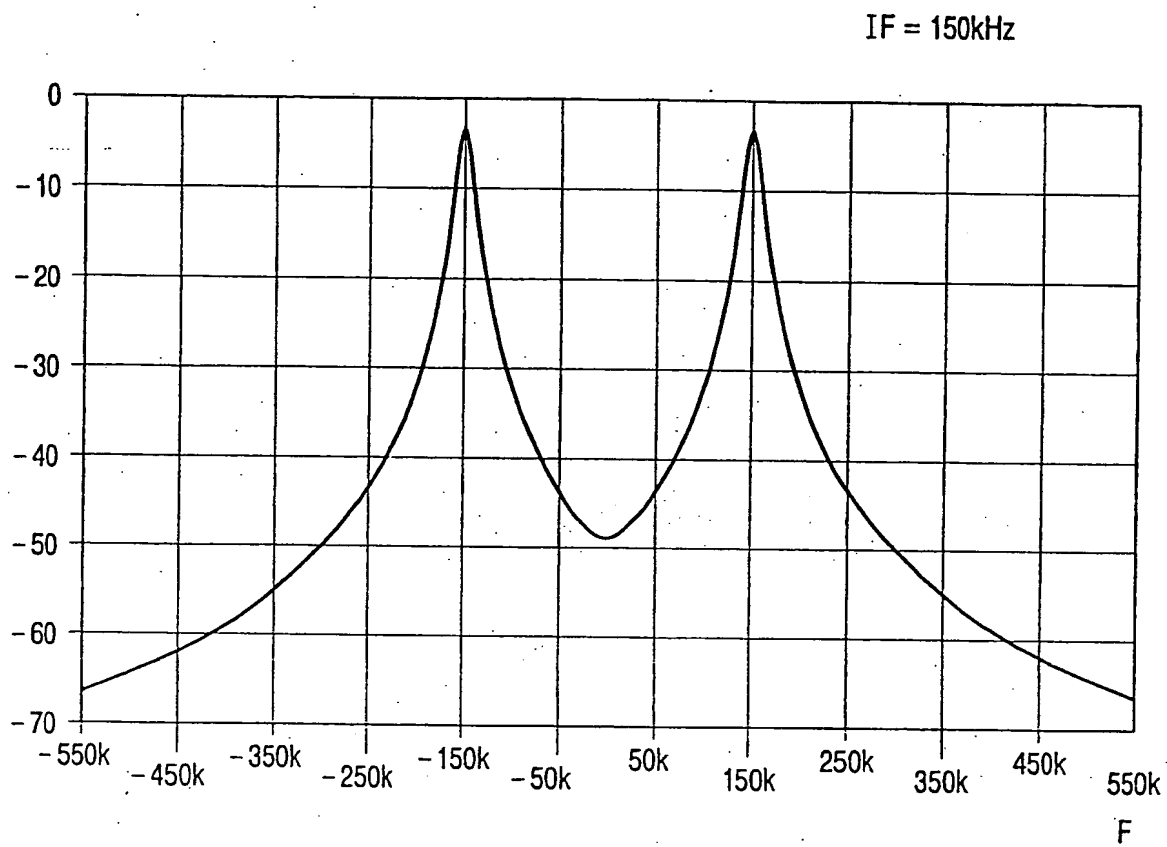


FIG. 1

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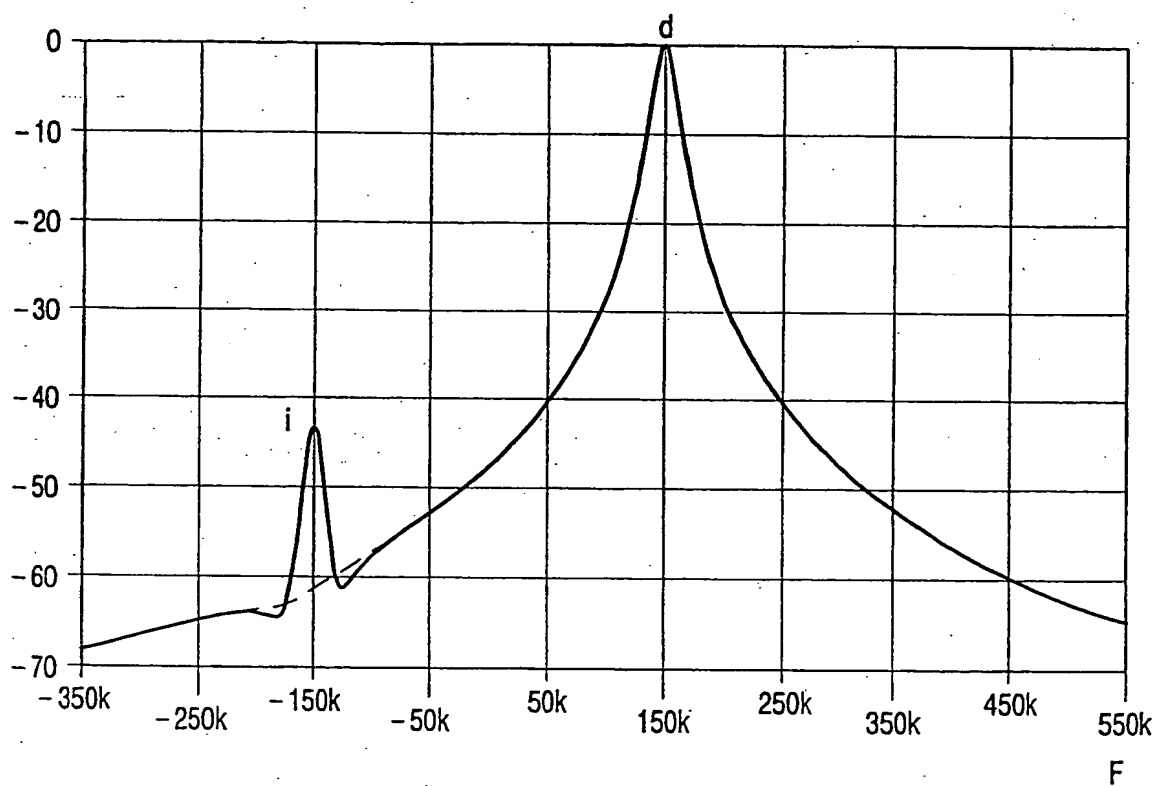


FIG. 2

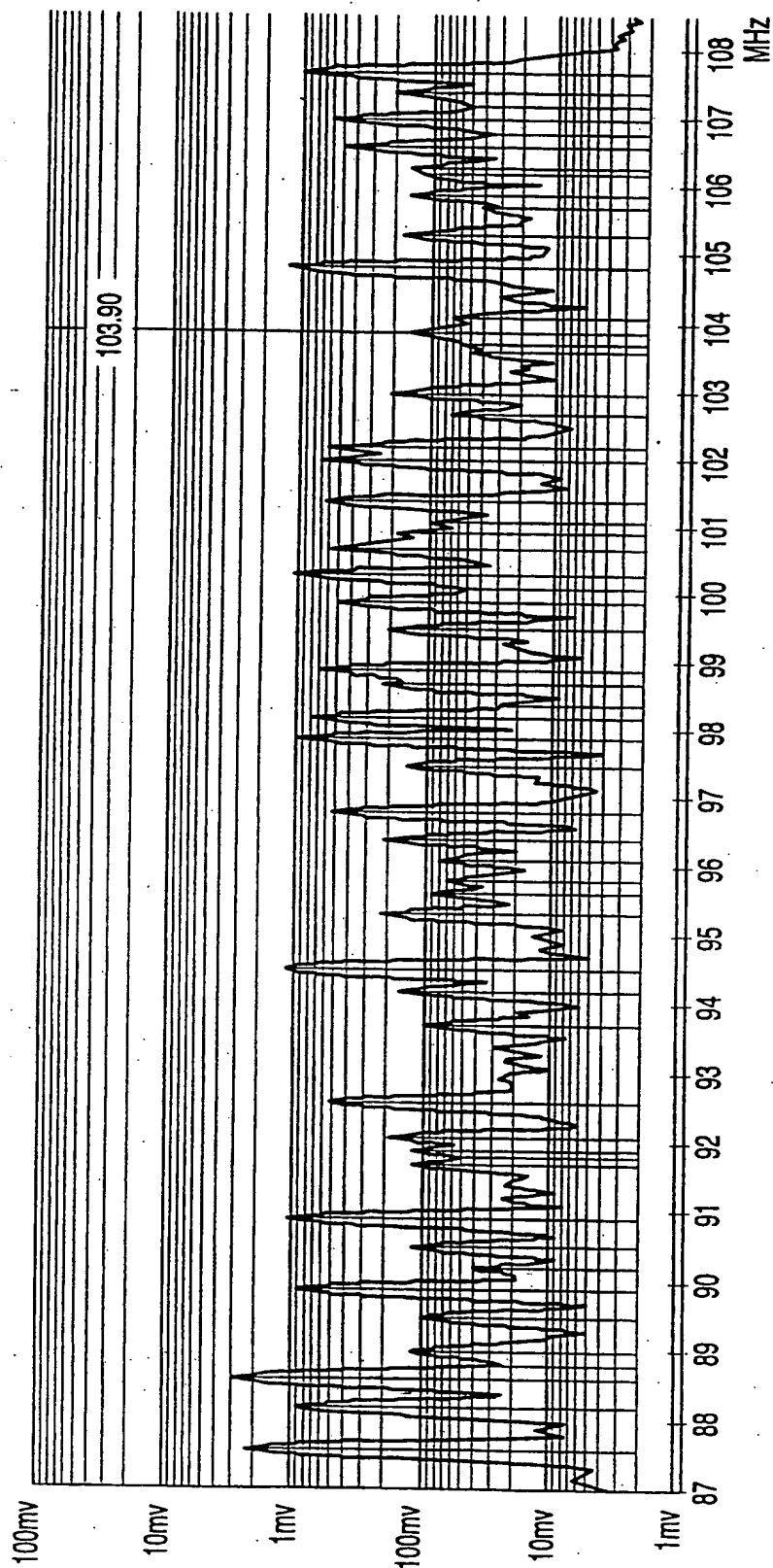


FIG. 3

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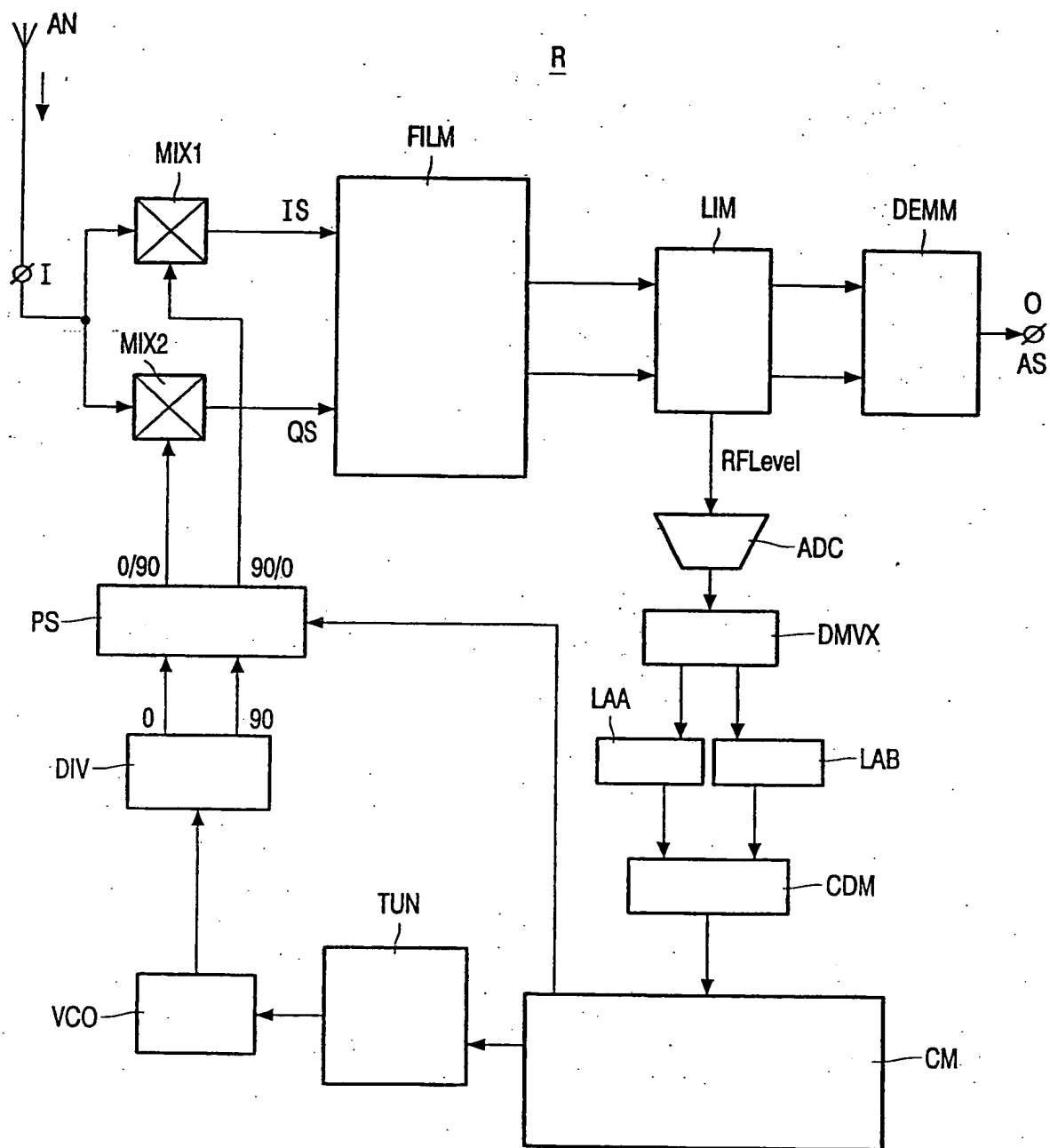


FIG. 4

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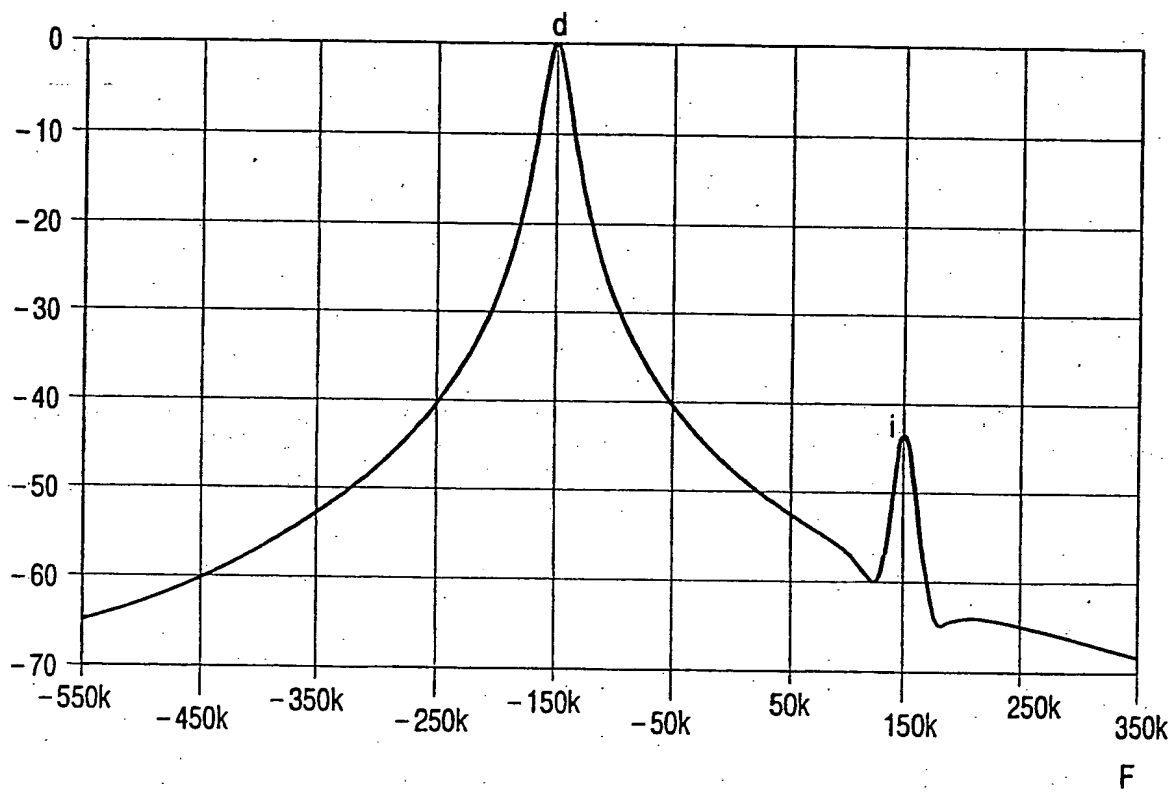


FIG. 5